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#07-107 Toward UO2 micro/macro machining: A Laser processing approach

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Linked to experimental data acquisition and to development of improved models, a better detailed description of the behaviour of the nuclear ceramics as regards the fission gases release during thermal transients representative of accidental conditions such as RIA (Reactivity Initiated Accident) or LOCA (LOss of Coolant Accident) requires access to local information within the fuel pellet, and not only averaged over the whole pellet. One of the major challenges in this context is the sample size, which depends on the main objective of the study, typically from the order of a few hundred microns to millimeters. Few techniques allow this scale dynamic while being compatible with irradiated fuel constraints. Laser micromachining is a high precision non-contact material removal process that would be adapted to this dynamic.

During a laser micromachining, the interaction between the laser beam (in our case infrared) with the material involves several thermal processes: absorption of the deposed energy, heating, thermal diffusion, fusion, vaporization. Depending on the experimental parameters, we can achieve material removal (ablation) with precise cutting edges. The lack of contact between the tool and the part allows micromachining of fragile samples, such as ceramics. However, the control of the Heat Affected Zone (HAZ) is generally critical and requires optimization of the operating parameters and a perfect control of the laser-material interactions, as well as the other induced effects (plasma generation, delamination, micro cracks, and denaturation of the target).

The present paper presents experimental and numerical studies, carried out in order to evaluate the possibility to apply this process for the preparation of irradiated UO2 samples of various dimensions. First, preliminary works conducted on materials which have comparable properties (in particular their behaviour under laser irradiation and their high melting point) in order to validate the feasibility of the process will be detailed. Afterwards, optimization of the global process will be presented. This has been done:
• by predicting the amount of material ablated for each laser pulse in order to perfectly control the micromachining,
• by controlling the dynamics of the laser spot displacement on the target, through a galvanometric head,
• and by multiplying the laser passes in order to obtain the desired depth.

Finally, numerical simulations performed by a finite element method to strengthen the experimental results in order to transfer the technique to non-irradiated UO2, and then to the irradiated material will be highlighted.

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